

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents
United States Patent and Trademark
Office
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Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 17 February 2000 (17.02.00)	
International application No. PCT/US99/15631	Applicant's or agent's file reference
International filing date (day/month/year) 09 July 1999 (09.07.99)	Priority date (day/month/year) 10 July 1998 (10.07.98)
Applicant KO, Wen, H. et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
05 January 2000 (05.01.00)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Nestor Santesso

Telephone No.: (41-22) 338.83.38

REC'D 07 NOV 2000

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

15

Applicant's or agent's file reference DN1999138		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US99/15631	International filing date (day/month/year) 09/07/1999	Priority date (day/month/year) 10/07/1998
International Patent Classification (IPC) or national classification and IPC B60C23/04		
Applicant THE GOODYEAR TIRE & RUBBER COMPANY et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


2. This REPORT consists of a total of 5 sheets, including this cover sheet.

- ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 05/01/2000	Date of completion of this report 03.11.2000
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Schmid, K Telephone No. +49 89 2399 8876



**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/US99/15631

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).):*

Description, pages:

2-7,9-41	as originally filed			
8,8a	as received on	20/06/2000	with letter of	12/06/2000
1	as received on	23/10/2000	with letter of	12/10/2000

Claims, No.:

1-5	as received on	23/10/2000	with letter of	12/10/2000
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Drawings, sheets:

1/7-7/7	as originally filed
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2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

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4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-5
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-5
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-5
	No:	Claims	

**2. Citations and explanations
see separate sheet**

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/US99/15631

concerning point V:

1. Claim 1

Document US-A-5 223 844 (D1) (page 8, lines 8 - 26) discloses a generic piezoelectric-powered tire revolution counter comprising piezoelectric strips on the tire's side wall.

The technical problem to be solved by the invention is to improve the energy conversion efficiency (page 19, lines 5 - 6),

To solve the said problem the subject-matter of independent claim 1 comprises a piezoelectric element which is in the form of a circular unimorph.

This feature is neither known nor rendered obvious from the available prior art.

Therefore, the piezoelectric-powered tire revolution counter according to claim 1, as well as the assembly, the vehicle and the central receiving station which are related to such a security system seem to fulfil the requirements of Article 33 PCT.

2. Claims 2 - 5

The dependent claims 2 - 5 refer to advantageous designs of a piezoelectric-powered tire revolution counter according to independent claim 1 and, therefore, they also seem to fulfil the requirements of Article 33 PCT.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/US99/15631

concerning point VII/:

The vague and imprecise statement ("spirit of the invention") in the description on page 41, last paragraph and page 12, line 22 implies that the subject-matter for which protection is sought may be different to that defined by the claims, thereby resulting in lack of clarity (Article 6 PCT) when used to interpret them (see also the PCT Guidelines, PCT/GL/3 III, 4.3a).

Page 18, line 6 ("... any form of piezo element could be utilized...") comprises subject-matter which is not covered by amended claim 1.

Therefore, these parts should be deleted.

DN1999138

SELF-POWERED TIRE REVOLUTION COUNTER

5

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of US Provisional Patent Application No. 60/092,270, filed 7/10/98 by Ko, et al.

10

TECHNICAL FIELD OF THE INVENTION

The invention relates to monitoring rotation of a pneumatic tire, with telemetry apparatus disposed in the tire.

15

BACKGROUND OF THE INVENTION**MONITORING TIRE CONDITIONS**

It is known to remotely monitor conditions of pneumatic tires of motor vehicles. For example, telemetry devices comprising an RF transmitter and one or more condition sensors may be disposed in each of the tires. A transponder and associated conditions sensors (e.g., pressure, temperature) may also be disposed in pneumatic tires of motor vehicles. A "transponder" is an electronic device capable of both receiving and transmitting radio frequency (RF) signals. These transponders transmit a RF wave, with or without variable data (e.g., pressure, temperature) and/or fixed data (e.g., tire ID) to outside the tire, and receive RF signals, with or without data, from outside the tire. A separate transponder is typically associated with each tire of a motor vehicle to monitor and transmit tire-related data. Typically, a single "interrogator" having both transmitting and receiving capabilities is used to communicate with the plurality of transponders. The interrogator may be "hand-

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When the counter reaches a predetermined count, it produces an enable signal. An encoder produces an encoded signal. A transmitter for transmitting a modulated radio signal receives the encoded signal for modulating a carrier frequency to produce a modulated radio signal. At least one of the encoder and transmitters are connected to the counter to be enabled by the enable signal.

IBM Technical Disclosure Bulletin (Vol. 39, No. 8, August 1996) pages 245-246 discloses a piezoelectric powered (batteryless) radio frequency identification tag (RFID) for tires XP000638201. As disclosed, IBM's RFID is combined with piezoelectric strips oriented radially on the tire's side wall. As the side wall flexes when the tire rotates, the piezoelectric material will generate electric power and information for the tag, wherein the information is indicative of the tire's rate of rotation, the tire's air pressure, and the load the tire is carrying. The waveform from the piezoelectric material will be rectified to form a DC waveform which will charge a capacitor and subsequently power the RFID tag. The DC voltage depends on the piezoelectric material used and the number of layers used. The tag uses the frequency of the waveform to calculate the speed the tire is turning. By counting the number of revolutions, the tag can also keep track of how far the tire has traveled. Each tag has a unique ID and some non-volatile memory.

Attention is also directed to the following, each of which is incorporated in its entirety by reference herein: USP 5,260,683 (Tanaka, et al.; 1993; a piezo element is deformed by tire pressure); and USP 5,581,023 (Handfield, et al.; 1996; pressure transducer including a piezo-resistive, variably-conductive layer).

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8A**PZT Piezo Elements**

Many crystals have been found to possess piezoelectric property. Until the late 1940's piezoelectric materials included quartz, Rochelle salt, tourmaline, ammonium
5 dihydrogen phosphate (ADP), and lithium sulfate monohydrate. Not only single crystal, but polycrystalline ceramics solid can present piezoelectricity after subjected to a "poling" field. Since 1957 lead zirconate-titanate (PZT)
10 solid-solution ceramics has become one of the most important piezoelectric materials which offers high piezoelectric coupling, wide operating temperature range, and a choice of useful variations in engineering parameter.

Piezoelectric ceramics are generally made by a solid state reaction of several oxides or carbonates, followed by
15 high temperature firing involving crystal grain growth, and the electric poling process. Most piezoelectric ceramics are solid solutions. Variation of chemical composition allows the optimizing of properties. The leading position of the PZT compositions is due to their intrinsically strong
20 piezoelectric effect and high Curie point, which allow a wide

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

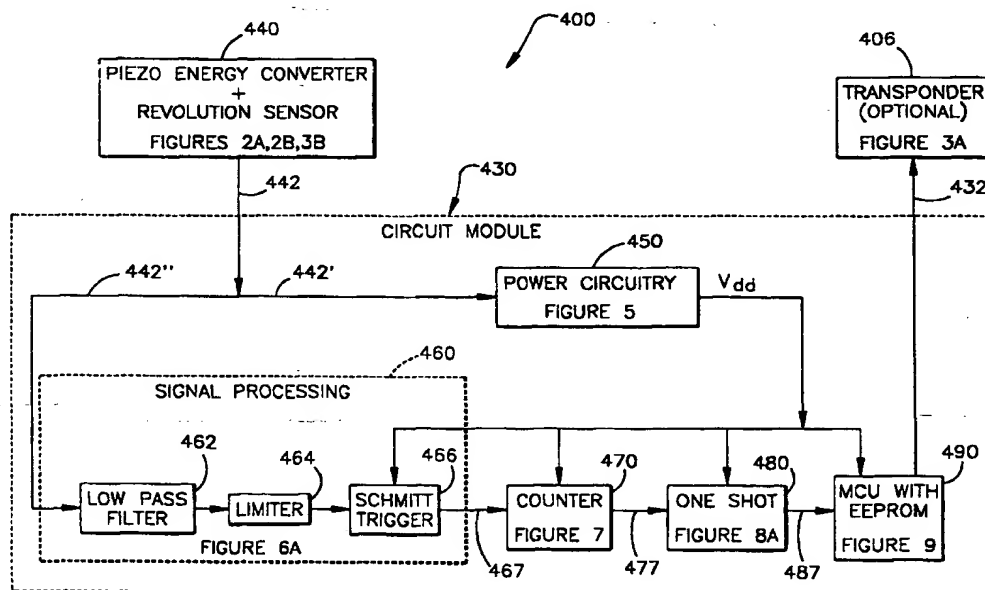
(51) International Patent Classification ⁷ : B60C 23/04, 23/06		A1	(11) International Publication Number: WO 00/02741
			(43) International Publication Date: 20 January 2000 (20.01.00)
(21) International Application Number: PCT/US99/15631 (22) International Filing Date: 9 July 1999 (09.07.99) (30) Priority Data: 60/092,270 10 July 1998 (10.07.98) US (71) Applicant (for all designated States except US): THE GOODYEAR TIRE & RUBBER COMPANY [US/US]; 1144 East Market Street, Akron, OH 44316-0001 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): KO, Wen, H. [US/US]; 1356 Forest Hills Boulevard, Cleveland Heights, OH 44118 (US). XIE, Huijun [CN/US]; 35 Yorkshire Terrace No. 10, Shrewsbury, MA 01545 (US). (74) Agent: COHN, Howard, M.; c/o Brown, Robert, W., Dept. 823, The Goodyear Tire & Rubber Company, 1144 East Market Street, Akron, OH 44309-3531 (US).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published With international search report.	

(54) Title: SELF-POWERED TIRE REVOLUTION COUNTER

(57) Abstract

The rotation of a pneumatic tire (304) is monitored by a self powered tire revolution counter (400). A piezoelectric ("piezo") element (200, 220, 340, 340', 440) is mounted in the tire in a manner so as to be subjected to periodic mechanical stresses as the tire rotates and to provide periodic pulses in response thereto. The output of the piezo element is utilized by revolution counting circuitry (460/470/480/490) to count rotations of the tire, as well as by power circuitry (450) which provides power to the revolution counting circuitry. The piezo element contains one or more piezoelectric crystals (204, 208, 224, 324) suitably

made of lead zirconate-titanate ("PZT"), and is preferably in the form of a circular unimorph (disc) (340'). Output pulses from the piezo element are rectified (452), filtered (454) and regulated (456) to supply power to the counting circuitry. Prior to counting the pulses, they are passed through a low pass filter (462) for attenuating high frequency signal noise in the pulses, then through a voltage limiter (464) to limit the voltage of the pulses, then through a Schmitt trigger (466) for interfacing the pulses with a counting circuit (470), then through a one shot circuit (480) for interfacing an output of the counting circuit with a microprocessor (490). The counting circuit can be set to output a signal only upon every "n" revolutions. Nonvolatile storage, preferably in the form of an EEPROM is provided to store instructions for operating the circuitry, as well as a measured count indicative of tire rotation for transmission by optional separate telemetry apparatus (406).



replaced by
Article 34

What is claimed is:

1. Self powered tire revolution counter (400),
5 comprising:

a piezoelectric element (200, 220, 340, 340', 440)
mounted in a pneumatic tire in a manner to be subjected to
periodic mechanical stresses as the tire (104, 304) rotates;

characterized by:

10 power circuitry (450) connected to the
piezoelectric element and having an output for supplying a DC
voltage (V_{dd}); and

a revolution counting circuit (460/470/480/490)
connected to the piezoelectric element.

15

2. Self powered tire revolution counter, according to
claim 1, characterized in that:

the piezoelectric element comprises at least one
piezoelectric crystal (204, 208, 224, 324) composed of lead
20 zirconate-titanate ($Pb(Zr_{1-x}Ti_x)O_3$), a metal supporting
element (206, 226, 326) bonded to a first side of each
piezoelectric crystal, and an electrode (202, 210, 222, 322)
metallized on a second side of each piezoelectric crystal.

25 3. Self powered tire revolution counter, according to
claim 1, characterized in that:

the piezoelectric element is in the form of a disc
(340').

30 4. Self powered tire revolution counter, according to
claim 1, characterized in that:

the piezoelectric crystal (324) is in the form of a
disc which is approximately 24 mm in diameter and 0.18 mm in
thickness, and is mounted concentrically to a support element

(326) which is approximately 42 mm in diameter and 0.22 mm in thickness.

5 5. Self powered tire revolution counter, according to claim 1, wherein the revolution counting circuit comprises:
 a signal processing circuit element (460);
 a digital logic circuit (470) for counting;
 a monostable vibrator circuit element (480) to expand the on-time in the signal pulse; and
10 a microcontroller circuit element (490) with non-volatile data storage for updating the revolution count in its non-volatile data storage, and for making the count available (432) to an optional external reading device (406).

15 6. Self powered tire revolution counter, according to claim 1, characterized in that:
 when the tire rotates on a vehicle-supporting surface, the piezoelectric element flexes, generating positive and negative going energy pulses; and
20 characterized by:
 a bridge rectifier (452) receiving the pulses from the piezoelectric element and providing voltage to a storage capacitor (C2).

25 7. Self powered tire revolution counter, according to claim 6, characterized by:
 a low pass filter (462) for attenuating high frequency signal noise in the energy pulses.

30 8. Self powered tire revolution counter, according to claim 6, characterized by:
 a voltage limiter (464) for limiting voltage from the storage capacitor.

9. Self powered tire revolution counter, according to claim 8, wherein the voltage limiter comprises:

forward and backward biased diodes (D1 and D2).

5 10. Self powered tire revolution counter, according to claim 9, characterized by:

a Schmitt trigger receiving an output of the forward and backward biased diodes, for converting a signal with relatively irregular shape to a clean square wave for
10 interfacing with the revolution counting circuit.

11. Self powered tire revolution counter, according to claim 1, wherein the revolution counting circuit comprises:

a low pass filter having an input connected to the piezoelectric element;
15

a limiter circuit connected to the low pass filter;

a Schmitt trigger connected to the limiter circuit;

a counter connected to the Schmitt trigger;

a one shot circuit connected to the counter; and

20 a microcontroller with non-volatile memory connected to the one shot circuit and making a serial output representing the updated total revolution count.

12. Self powered tire revolution counter, according to claim 1, wherein the power circuitry (450) comprises:
25

a rectifier circuit having an input connected to the piezoelectric element;

a filter connected to the rectifier circuit; and

a regulator connected to the filter and providing a
30 DC output voltage (Vdd).

ARTICLE 34

42

What is claimed is:

1. Piezoelectric-powered tire revolution counter (400), including:

5 a piezoelectric element (200, 220, 340, 340', 440) mounted in a pneumatic tire in a manner to be subjected to periodic mechanical stresses as the tire (104, 304) rotates; power circuitry (450) connected to the piezoelectric element and having an output for supplying a DC
10 voltage (V_{dd}) to power circuitry of the revolution counter; and

a revolution counting circuit (460/470/480/490) connected to the piezoelectric element; characterized in that:

15 the piezoelectric element is in the form of a circular unimorph (340').

2. Piezoelectric-powered tire revolution counter, according to claim 1, wherein:

20 the piezoelectric element circular unimorph comprises a piezoelectric crystal (324) formed as a circular plate; a support element (326) formed as a circular plate and bonded to a first side of the piezoelectric crystal; and an electrode (322) coated on a second side of the piezoelectric
25 crystal, characterized in that:

the support element is a brass plate which has a larger diameter than the piezoelectric crystal.

3. Piezoelectric-powered tire revolution counter, according to claim 2, characterized in that:

30 the piezoelectric crystal is approximately 24 mm in diameter and 0.18 mm in thickness, and is mounted concentrically to the support element which is approximately 42 mm in diameter and 0.22 mm in thickness.

4. Piezoelectric-powered tire revolution counter,
according to claim 2, characterized in that:

the piezoelectric crystal is composed of lead
5 zirconate-titanate ($\text{Pb}(\text{Zr}_{1-x}\text{Ti}_x)\text{O}_3$).

5. Piezoelectric-powered tire revolution counter,
according to claim 1, wherein the revolution counting circuit
is characterized by:

10 a signal processing circuit element (460), having a
low pass filter (462) for attenuating high frequency signal
noise in the energy pulses; a voltage limiter (464)
comprising forward and backward biased diodes (D1 and D2) for
limiting voltage and current in the signal; and a Schmitt
15 trigger receiving an output of the forward and backward
biased diodes, for converting a signal with relatively
irregular shape to a clean square wave for interfacing with
the revolution counting circuit;

a digital logic circuit (470) for counting;

20 a monostable vibrator circuit element (480) to
expand the on-time in the signal pulse; and

a microcontroller circuit element (490) with non-
volatile data storage for updating the revolution count in
its non-volatile data storage, and for making the count
25 available (432) to an optional external reading device (406).

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

COHN, H.
The Goodyear Tire and Rubber Comp.
c/o Robert W. Brown-Dept 823
1144 East Market Street
Akron, Ohio 44309-3531
ETATS-UNIS D'AMERIQUE

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NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT (PCT Rule 71.1)

Date of mailing (day/month/year)	03.11.2000
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Applicant's or agent's file reference DN1999138	IMPORTANT NOTIFICATION
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International application No. PCT/US99/15631	International filing date (day/month/year) 09/07/1999	Priority date (day/month/year) 10/07/1998
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Applicant THE GOODYEAR TIRE & RUBBER COMPANY et al.
--

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.
4. **REMINDER**

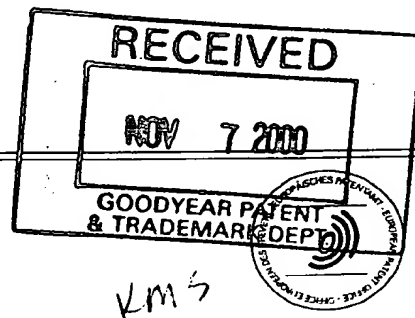
The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
---------------------------------------	--------------------

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PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference DN1999138	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
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- VIII ☒ Certain observations on the international application

Date of submission of the demand 05/01/2000	Date of completion of this report 03.11.2000
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Schmid, K Telephone No. +49 89 2399 8876 

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/US99/15631

I. Basis of the report

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Claims, No.:

1-5	as received on	23/10/2000	with letter of	12/10/2000
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Drawings, sheets:

1/7-7/7	as originally filed
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2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

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- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/US99/15631

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims 1-5
	No: Claims
Inventive step (IS)	Yes: Claims 1-5
	No: Claims
Industrial applicability (IA)	Yes: Claims 1-5
	No: Claims

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

concerning point V:

1. Claim 1

Document US-A-5 223 844 (D1) (page 8, lines 8 - 26) discloses a generic piezoelectric-powered tire revolution counter comprising piezoelectric strips on the tire's side wall.

The technical problem to be solved by the invention is to improve the energy conversion efficiency (page 19, lines 5 - 6),

To solve the said problem the subject-matter of independent claim 1 comprises a piezoelectric element which is in the form of a circular unimorph.

This feature is neither known nor rendered obvious from the available prior art.

Therefore, the piezoelectric-powered tire revolution counter according to claim 1, as well as the assembly, the vehicle and the central receiving station which are related to such a security system seem to fulfil the requirements of Article 33 PCT.

2. Claims 2 - 5

The dependent claims 2 - 5 refer to advantageous designs of a piezoelectric-powered tire revolution counter according to independent claim 1 and, therefore, they also seem to fulfil the requirements of Article 33 PCT.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/US99/15631

concerning point VII:

The vague and imprecise statement ("spirit of the invention") in the description on page 41, last paragraph and page 12, line 22 implies that the subject-matter for which protection is sought may be different to that defined by the claims, thereby resulting in lack of clarity (Article 6 PCT) when used to interpret them (see also the PCT Guidelines, PCT/GL/3 III, 4.3a).

Page 18, line 6 ("... any form of piezo element could be utilized...") comprises subject-matter which is not covered by amended claim 1.

Therefore, these parts should be deleted.

M 20.06.00
8

When the counter reaches a predetermined count, it produces an enable signal. An encoder produces an encoded signal. A transmitter for transmitting a modulated radio signal receives the encoded signal for modulating a carrier
5 frequency to produce a modulated radio signal. At least one of the encoder and transmitters are connected to the counter to be enabled by the enable signal.

IBM Technical Disclosure Bulletin (Vol. 39, No. 8, August 1996) pages 245-246 discloses a piezoelectric powered
10 (batteryless) radio frequency identification tag (RFID) for tires XP000638201. As disclosed, IBM's RFID is combined with piezoelectric strips oriented radially on the tire's side wall. As the side wall flexes when the tire rotates, the piezoelectric material will generate electric power and
15 information for the tag, wherein the information is indicative of the tire's rate of rotation, the tire's air pressure, and the load the tire is carrying. The waveform from the piezoelectric material will be rectified to form a DC waveform which will charge a capacitor and subsequently
20 power the RFID tag. The DC voltage depends on the piezoelectric material used and the number of layers used. The tag uses the frequency of the waveform to calculate the speed the tire is turning. By counting the number of revolutions, the tag can also keep track of how far the tire
25 has traveled. Each tag has a unique ID and some non-volatile memory.

Attention is also directed to the following, each of which is incorporated in its entirety by reference herein: USP 5,260,683 (Tanaka, et al.; 1993; a piezo element is
30 deformed by tire pressure); and USP 5,581,023 (Handfield, et al.; 1996; pressure transducer including a piezo-resistive, variably-conductive layer).

M 20.05.00
8A

PZT Piezo Elements

Many crystals have been found to possess piezoelectric property. Until the late 1940's piezoelectric materials included quartz, Rochelle salt, tourmaline, ammonium
5 dihydrogen phosphate (ADP), and lithium sulfate monohydrate. Not only single crystal, but polycrystalline ceramics solid can present piezoelectricity after subjected to a "poling" field. Since 1957 lead zirconate-titanate (PZT)
10 solid-solution ceramics has become one of the most important piezoelectric materials which offers high piezoelectric coupling, wide operating temperature range, and a choice of useful variations in engineering parameter.

Piezoelectric ceramics are generally made by a solid state reaction of several oxides or carbonates, followed by
15 high temperature firing involving crystal grain growth, and the electric poling process. Most piezoelectric ceramics are solid solutions. Variation of chemical composition allows the optimizing of properties. The leading position of the PZT compositions is due to their intrinsically strong
20 piezoelectric effect and high Curie point, which allow a wide

DN1999138

SELF-POWERED TIRE REVOLUTION COUNTER

5

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of US Provisional Patent Application No. 60/092,270, filed 7/10/98 by Ko, et al.

10

TECHNICAL FIELD OF THE INVENTION

The invention relates to monitoring rotation of a pneumatic tire, with telemetry apparatus disposed in the tire.

15

BACKGROUND OF THE INVENTION**MONITORING TIRE CONDITIONS**

It is known to remotely monitor conditions of pneumatic tires of motor vehicles. For example, telemetry devices comprising an RF transmitter and one or more condition sensors may be disposed in each of the tires. A transponder and associated conditions sensors (e.g., pressure, temperature) may also be disposed in pneumatic tires of motor vehicles. A "transponder" is an electronic device capable of both receiving and transmitting radio frequency (RF) signals. These transponders transmit a RF wave, with or without variable data (e.g., pressure, temperature) and/or fixed data (e.g., tire ID) to outside the tire, and receive RF signals, with or without data, from outside the tire. A separate transponder is typically associated with each tire of a motor vehicle to monitor and transmit tire-related data. Typically, a single "interrogator" having both transmitting and receiving capabilities is used to communicate with the plurality of transponders. The interrogator may be "hand-

20
25
30

What is claimed is:

1. Piezoelectric-powered tire revolution counter (400), including:

- 5 a piezoelectric element (200, 220, 340, 340', 440) mounted in a pneumatic tire in a manner to be subjected to periodic mechanical stresses as the tire (104, 304) rotates; power circuitry (450) connected to the piezoelectric element and having an output for supplying a DC
10 voltage (V_{dd}) to power circuitry of the revolution counter; and
 a revolution counting circuit (460/470/480/490) connected to the piezoelectric element;
 characterized in that:
15 the piezoelectric element is in the form of a circular unimorph (340').

2. Piezoelectric-powered tire revolution counter, according to claim 1, wherein:

- 20 the piezoelectric element circular unimorph comprises a piezoelectric crystal (324) formed as a circular plate; a support element (326) formed as a circular plate and bonded to a first side of the piezoelectric crystal; and an electrode (322) coated on a second side of the piezoelectric
25 crystal, characterized in that:
 the support element is a brass plate which has a larger diameter than the piezoelectric crystal.

3. Piezoelectric-powered tire revolution counter, according to claim 2, characterized in that:

30 the piezoelectric crystal is approximately 24 mm in diameter and 0.18 mm in thickness, and is mounted concentrically to the support element which is approximately 42 mm in diameter and 0.22 mm in thickness.

4. Piezoelectric-powered tire revolution counter,
according to claim 2, characterized in that:

the piezoelectric crystal is composed of lead
5 zirconate-titanate ($\text{Pb}(\text{Zr}_{1-x}\text{Ti}_x)\text{O}_3$).

5. Piezoelectric-powered tire revolution counter,
according to claim 1, wherein the revolution counting circuit
is characterized by:

10 a signal processing circuit element (460), having a
low pass filter (462) for attenuating high frequency signal
noise in the energy pulses; a voltage limiter (464)
comprising forward and backward biased diodes (D1 and D2) for
limiting voltage and current in the signal; and a Schmitt
15 trigger receiving an output of the forward and backward
biased diodes, for converting a signal with relatively
irregular shape to a clean square wave for interfacing with
the revolution counting circuit;

a digital logic circuit (470) for counting;
20 a monostable vibrator circuit element (480) to
expand the on-time in the signal pulse; and

a microcontroller circuit element (490) with non-
volatile data storage for updating the revolution count in
its non-volatile data storage, and for making the count
25 available (432) to an optional external reading device (406).

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference DN1999138	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 99/ 15631	International filing date (day/month/year) 09/07/1999	(Earliest) Priority Date (day/month/year) 10/07/1998
Applicant THE GOODYEAR TIRE & RUBBER COMPANY et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :



contained in the international application in written form.



filed together with the international application in computer readable form.



furnished subsequently to this Authority in written form.



furnished subsequently to this Authority in computer readable form.



the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.



the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,



the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,



the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

4



as suggested by the applicant.



because the applicant failed to suggest a figure.



because this figure better characterizes the invention.



None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/15631

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B60C23/04 B60C23/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B60C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 307 044 A (JESSOP JOHN MICHAEL) 14 May 1997 (1997-05-14) page 6, line 1 -page 7, line 9; figures 1,2 ---	1,5
X	US 5 546 070 A (ELLMANN MANFRED ET AL) 13 August 1996 (1996-08-13) column 2, line 17 - line 58; figures 1,2 ---	1
A	US 4 862 486 A (WING J KEITH ET AL) 29 August 1989 (1989-08-29) column 1, line 66 -column 2, line 35; claims 5,6; figures --- -/--	11

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

27 October 1999

Date of mailing of the international search report

03/11/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Hageman, L

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/15631

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>"PIEZOELECTRIC POWERED (BATTERYLESS) RADIO FREQUENCY IDENTIFICATION TAG FOR TIRES" IBM TECHNICAL DISCLOSURE BULLETIN, vol. 39, no. 8, 1 August 1996 (1996-08-01), page 245/246 XP000638201 ISSN: 0018-8689 the whole document</p> <p style="text-align: center;">-----</p>	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/15631

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB 2307044	A	14-05-1997	WO	9717218 A	15-05-1997
US 5546070	A	13-08-1996	DE	4329591 A	09-03-1995
			DE	59404812 D	29-01-1998
			EP	0641679 A	08-03-1995
US 4862486	A	29-08-1989	NONE		

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:

The Goodyear Tire and Rubber Comp.
c/o Robert W. Brown-Dept 823
Attn. COHN, H.
1144 East Market Street
Akron, Ohio 44309-3531
UNITED STATES OF AMERICA

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing (day/month/year) 03/11/1999	
Applicant's or agent's file reference DN1999138	FOR FURTHER ACTION See paragraphs 1 and 4 below
International application No. PCT/US 99/ 15631	International filing date (day/month/year) 09/07/1999
Applicant THE GOODYEAR TIRE & RUBBER COMPANY et al.	

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.


4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority

 European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.
Fax: (+31-70) 340-3016

Authorized officer

Germaine Moet

RECEIVED

NOV 11 1999

GOODYEAR PATENT
& TRADEMARK DEPT.

mms

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

NOTES TO FORM PCT/ISA/220 (continued)

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference DN1999138	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 99/ 15631	International filing date (day/month/year) 09/07/1999	(Earliest) Priority Date (day/month/year) 10/07/1998
Applicant THE GOODYEAR TIRE & RUBBER COMPANY et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:



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furnished subsequently to this Authority in written form.



furnished subsequently to this Authority in computer readable form.



the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.



the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,



the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,



the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

4



as suggested by the applicant.



because the applicant failed to suggest a figure.



because this figure better characterizes the invention.



None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/15631

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B60C23/04 B60C23/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B60C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 307 044 A (JESSOP JOHN MICHAEL) 14 May 1997 (1997-05-14) page 6, line 1 -page 7, line 9; figures 1,2 ---	1,5
X	US 5 546 070 A (ELLMANN MANFRED ET AL) 13 August 1996 (1996-08-13) column 2, line 17 - line 58; figures 1,2 ---	1
A	US 4 862 486 A (WING J KEITH ET AL) 29 August 1989 (1989-08-29) column 1, line 66 -column 2, line 35; claims 5,6; figures --- -/--	11



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

27 October 1999

Date of mailing of the international search report

03/11/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Hageman, L

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/15631

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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